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(54) **Electron accelerator**

Elektronenbeschleuniger

Accélérateur d'électrons

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(56) References cited:
US-A- 3 388 280 **US-A- 3 864 572**

- **PATENT ABSTRACTS OF JAPAN, vol. 5, no. 55 (E-52)[727], 16th April 1981; & JP-A- 56 6363 (NIPPON DENSHI) 22-01-1981**
- **PATENT ABSTRACTS OF JAPAN, vol. 12, no. 32 (E-76)[1507], 29th March 1977; & JP- A-51 127 671 (HITACHI) 11-06-1976**

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Description

The present invention relates to an electron accelerator for electrostatical acceleration of electrons emitted from a hot cathode provided in a vacuum vessel.

An electron accelerator is used in various industrial fields such as graft polymerization, antipollution for air and material analysis. Fig. 1 shows the construction of an example of an electron accelerator. In a vacuum vessel 10, a cathode 1, a truncated-cone-shaped bias electrode 2 disposed just in front of the cathode 1, an extracting electrode 3 having a central aperture for passing an electron beam and a group of electrostatic lenses 4 having central apertures are arranged in the preceding order along a central axis X to form an accelerated electron beam. At an exit of the accelerated electron beam, a titanic film window 5 is formed on a wall of the vacuum vessel 10. The accelerated electron beam is detected at an electron detecting electrode 12, which is set outside the window 5.

A DC high voltage is applied to the extracting electrode 3 and the electrostatic lenses 4 through a series of a resistors 14 across which a DC high voltage power supply 16 is connected. The cathode 1 is heated by an adjustable power supply 18. A DC power supply 20 is connected between the cathode 1 and the bias electrode 2, so that the electrical potential of the bias electrode 2 is lower than that of the cathode 1. The power supply 18 and 20 are given electrical power through an insulating transformer 22 from an AC power supply 24.

When this electron accelerator is driven, the cathode 1 is made red hot and thermal electrons are extracted from the hot cathode 1 by the extracting electrode 3. Since the bias electrode 2 has the central aperture for passing the electrons and is held in such an above-mentioned electric potential, the bias electrode 2 serves to focus the electron beam through the central portion of the extracting electrode 3. The electron beam then passes through the central apertures of the electrostatic lenses 4 which serve not only focusing but also accelerating for the electron beam. During the passage through the lenses 4, the electron beam is repeatedly converged and accelerated to form an accelerated electron beam and emitted through the titanic film window 5 to the outside. An electric current proportional to an amount of electron beam impinging on the detecting electrode 12 is converted to an AC current by a DC/AC converter 26. This AC current is fed through an insulating transformer 28 to an AC/DC converter 30 which converts the AC current to a DC current which is then fed back to the power supply 18. This negative feed back loop controls the power supply 18 so that the cathode 1 is heated on a temperature at which an amount of the accelerated electron beam remains constant.

It is noted that the detecting electrode 12 can be provided inside the vacuum vessel 10.

US-A-3,865,572 shows an electron source of an electron beam apparatus which comprises besides an anode also a cathode wire having a tip which is to be heated by a laser beam. Further, means are provided for controlling the intensity of radiation focused on said tip in accordance with the anode current of a second anode in a direction which tends to maintain constant said anode current of said second anode.

Further, attention is drawn to US-A-3 388 280 which shows an electron discharge device of the hot cathode type, in which the cathode is heated by a laser-type beam including infra-red heat rays.

On an electron accelerator, a high voltage power supply are required to obtain a high energy electron beam. For example, a DC high voltage power supply of 1 MV, 100 mA is required to obtain an electron beam with 1 MeV and 100 mA. On the other hand, since the detecting electrode 12 is kept at ground potential, the potential difference between the power supply 18 and the detecting electrode 12 is significantly large. In order to tolerate such a high potential difference, the insulating transformers 22 and 28 have to be substantially large and are, as a result, expensive. In other words, the size and cost of the electron accelerator both become disadvantageous.

An object of the present invention is to provide an electron accelerator which is compact in size and capable of stably generating a high energy electron beam at a low cost.

According to the invention, an electron accelerator as set forth in claim 1 is provided. Preferred embodiments of the invention are shown in the dependent claims.

The above and other objects and advantages of the invention will become clearer from consideration of the following description taken in connection with the accompanying drawings illustrating certain embodiments.

Fig. 1 is a block diagram schematically showing the structure of an electron accelerator of the prior art;
Fig. 2 is a block diagram schematically showing the structure of an electron accelerator of an embodiment according to the present invention; and
Fig. 3 is a block diagram schematically showing the structure of another electron accelerator, which, however, does not fall within the scope of the claims.

Fig. 2 schematically shows the construction of an embodiment of an electron accelerator according to the invention. In this figure, similar or corresponding elements are designated by the same reference numerals as used in Fig. 1 and an explanation thereof is omitted here.

A cathode 32 in the vacuum vessel 10 is composed of an oxide of Br, Sr or Ca, or LaB_6. The bias electrode 2 having the central aperture for passing the electron beam is disposed adjacent to the surface of the cathode 32. In front of the bias electrode 2, the doughnut-type extracting electrode 3 and the group of electrostatic

lenses 4 are arranged along the central axis along which the electron beam travels, and a high voltage is supplied to the electrodes through the divider resistors 14 connected in series to the DC high voltage power supply 16.

A resistor 34 is connected between the cathode 32 and the DC power supply 16. The bias electrode 2 is connected to the DC power supply 16.

A quartz rod 36 is mounted to the vacuum vessel 10 such that one end thereof is immediately adjacent to the cathode 32 and that the other end thereof protrudes out of the vacuum vessel 10. An infrared lamp 38 is disposed facing the protruding end of the quartz rod 36. The infrared lamp 38 is connected to a power supply 40 to which the detecting electrode 12 feeds back a signal through an amplifier 42.

In operation, an infrared ray emitted from the infrared lamp 38 travels through the quartz rod 36 while being completely reflected by the inner surface of the quartz rod 36 and illuminates the cathode 32 provided in the vacuum vessel 10, causing the cathode 32 to become red hot. The cathode 32 such as an oxide of Br, Sr and/or Ca or LaB_6 emits a great number of thermal electrons when the cathode 32 is heated to 700 - 1500°C.

As a high voltage is applied to the extracting anode 3 and the group of electrostatic lenses 4 from the DC high voltage power supply 16, the thermal electrons are first extracted toward the extracting anode 3. The bias electrode 2 is kept at a lower potential by the resistor 34 than the cathode 32 and the emitted electrons are repelled by the bias electrode 2 and consequently limited to a narrow beam. This electron beam passes through the center of the central aperture formed on the bias electrode 2 without expanding and passes to the electrostatic lenses 4 which serve to accelerate the electron beam to form an accelerated electron beam X.

The detecting electrode 12 disposed on a path of the accelerated electron beam in the vacuum vessel 10 generates a signal proportional to the current of the incoming accelerated electron beam. The signal is amplified by the amplifier 42 and fed back to the power supply 40 which then controls the intensity of light emitted from the infrared lamp 38 to adjust the temperature of the thermal cathode 32 so that the level of the accelerated electron beam may be kept constant.

As can be understood from the foregoing description, in the electron accelerator, complete electrical insulation is provided between the cathode 32 and the infrared lamp 38 through the quartz rod 36 without any insulating transformer. This enables a feedback loop having a simple structure to be used.

Fig. 3 schematically shows the construction of another electron accelerator. In this figure, similar or corresponding elements are designated by the same reference numerals as used in Fig. 2 and explanation thereof is omitted here.

An electron accelerator according to this embodiment is intended to heat the cathode 32 with a laser beam, and includes a high power laser head 44 and a window 46 mounted on the vacuum vessel 10 instead of the quartz rod 36 and the infrared lamp 38. The window 46 transmits a laser beam from the high power laser head 44. The laser head 44 is connected to power supply 48 which is controled by the feedback signal from the amplifier 42.

The present invention has been described in detail with particular reference to one embodiment of the invention, but it is to be understood that modifications and variations can be effected without departing from the scope of the invention as defined in the appended claims.

Claims

1. An electron accelerator including a thermal cathode (32) for electron emission, an accelerating section (4) connected to a high voltage power supply (16) for acceleration of electrons and a vacuum vessel (10) containing the cathode and the accelerating section, said apparatus comprising:

   first means (38) for heating said cathode (32) by an infrared ray;
   second means (12) for detecting a level of an electron beam accelerated by said accelerating section and for generating a signal proportional to the detected level; and
   third means (42) for feeding the signal back to said first means (38) so as to adjust the intensity of the heating ray to prevent the level of electrons emitted from said cathode (32) from fluctuating,
   wherein said first means (38) includes a quartz rod (36) for guiding the infrared ray, a ray source (38) and a power supply (40) for the source.

2. The apparatus as claimed in Claim 1 wherein said second means (12) includes an electrode (12) for detecting the level of said accelerated electron beam and wherein said third means (42) feeds back the signal from said detecting electrode (12) to the power supply (40) to control the intensity of said ray source (38) to cause said cathode (32) to emit a substantially constant level of electrons.

3. The apparatus as claimed in Claim 1 or 2 further including a laser beam for heating said cathode (32).

4. The apparatus as claimed in Claim 3 wherein an electrode for detecting the level of said accelerated electron beam is included and wherein the signal from said detecting electrode is fed back to the laser power supply to control said cathode to emit a sub-

stantially constant level of electrons.

Patentansprüche

1. Elektronenbeschleunigungsvorrichtung mit einer thermischen Kathode (32) zur Elektronenemission, einem Beschleunigungsabschnitt (4) verbunden mit einer Hochspannungsleistungsquelle (16) zur Beschleunigung der Elektronen und mit einem Vakuumgefäß (10), welches die Kathode und den Beschleunigungsabschnitt enthält, wobei die Vorrichtung folgendes aufweist:

   erste Mittel (38) zum Erhitzen der Kathode (32) durch einen Infrarotstrahl;
   zweite Mittel (12) zum Detektieren eines Pegels des Elektronenstrahls beschleunigt durch den erwähnten Beschleunigungsabschnitt und zur Erzeugung eines Signals proportional zum detektierten Pegel; und
   dritte Mittel (42) zum Zurückspeisen des Signals zu den ersten Mitteln (38) um so die Intensität des Erhitzungsstrahls einzustellen um zu verhindern, daß der Pegel der von der Kathode (32) emittierten Elektronen fluktuiert, wobei
   die ersten Mittel (38) eine Quarzstange (36) aufweisen zum Führen des infraroten Strahls, eine Strahlenquelle (38) und eine Leistungsversorgung (40) für die Quelle.

2. Vorrichtung nach Anspruch 1, wobei die zweiten Mittel (12) eine Elektrode (12) aufweisen zum Detektieren des Pegels des beschleunigten Elektronenstrahls, wobei die dritten Mittel (42) das Signal von der Detektierelektrode (12) zurück zur Leistungsversorgung (40) speisen oder koppeln, um die Intensität der Strahlungsquelle (38) zu steuern um zu bewirken, daß die Kathode (32) einen im wesentlichen konstanten Pegel von Elektronen emittiert.

3. Vorrichtung nach Anspruch 1 oder 2, wobei ferner ein Laserstrahl zum Erhitzen der Kathode (32) vorgesehen ist.

4. Vorrichtung nach Anspruch 3, wobei eine Elektrode zum Detektieren des Pegels des beschleunigten Elektronenstrahls vorgesehen ist, und wobei das Signal von der Detektionselektrode zurück zur Laserleistungsversorgung gekoppelt wird, um die Kathode zu steuern, und zwar zum Emittieren von Elektronen mit im wesentlichen konstantem Pegel.

Revendications

1. Accélérateur d'électrons comprenant une cathode thermique (32) pour une émission d'électrons, une section d'accélération (4) reliée à une alimentation à haute tension (16) pour une accélération d'électrons et un récipient sous vide (10) contenant la cathode et la section d'accélération, ledit appareil comprenant :

   des premiers moyens (38) pour chauffer ladite cathode (32) par un rayonnement infrarouge ;
   des deuxièmes moyens (12) pour détecter une intensité de faisceau d'électrons accéléré par ladite section d'accélération et pour produire un signal proportionnel à l'intensité détectée ; et
   des troisièmes moyens (42) pour ramener le signal auxdits premiers moyens (38) de manière à ajuster l'intensité du rayonnement chauffant pour empêcher la quantité d'électrons émis depuis ladite cathode (32) de fluctuer,
   dans lequel lesdits premiers moyens (38) comprennent une tige en quartz (36) pour guider le rayonnement infrarouge, une source de rayonnement (38) et une alimentation (40) pour la source.

2. Appareil selon la revendication 1, dans lequel lesdits deuxièmes moyens (12) comprennent une électrode (12) pour détecter l'intensité dudit faisceau accéléré d'électrons et dans lequel lesdits troisièmes moyens (42) ramènent le signal de ladite électrode de détection (12) à l'alimentation (40) pour commander l'intensité de ladite source de rayonnement (38) afin d'amener ladite cathode (32) à émettre un débit sensiblement constant d'électrons.

3. Appareil selon la revendication 2, comprenant en outre un faisceau de laser pour chauffer ladite cathode (32).

4. Appareil selon la revendication 3, dans lequel une électrode pour détecter l'intensité dudit faisceau accéléré d'électrons est incluse et dans lequel le signal de ladite électrode de détection est ramené à l'alimentation du laser pour commander à ladite cathode d'émettre un niveau sensiblement constant d'électrons.

FIg. 1

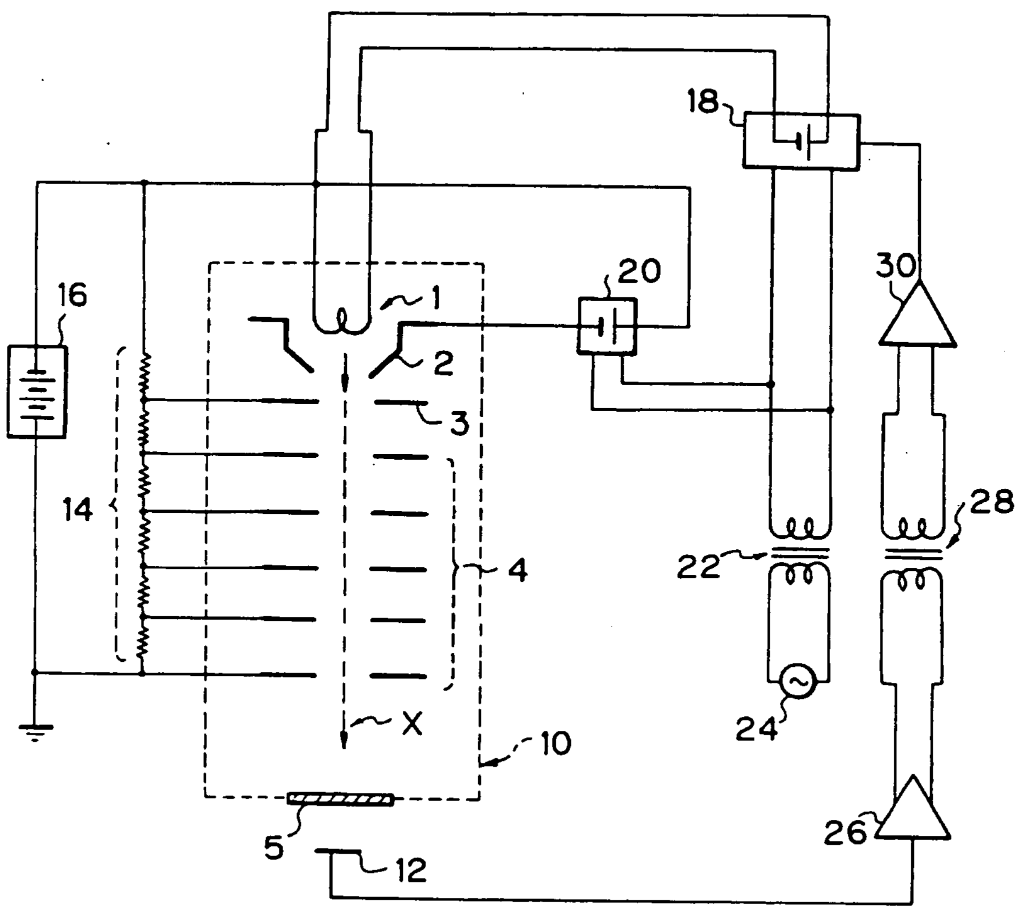

Fig. 2

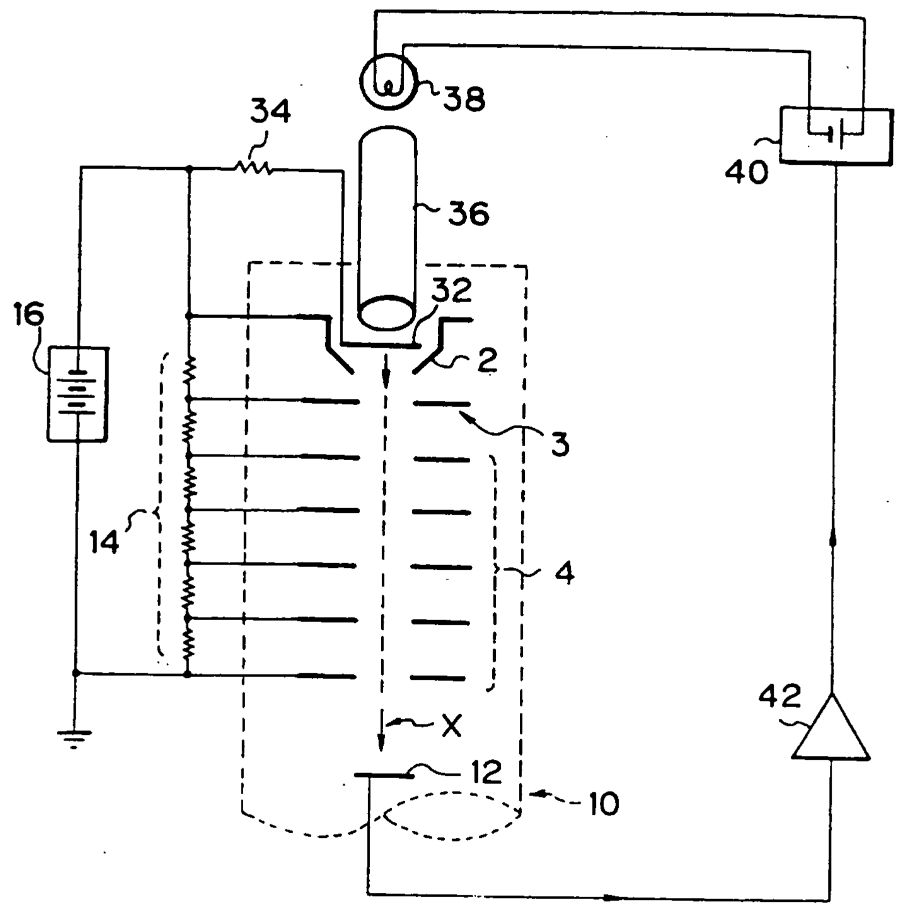

FIg. 3